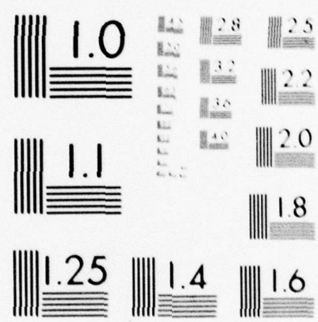
AD-A055 323 COAST GUARD WASHINGTON D C OFFICE OF MERCHANT MARINE--ETC F/G 6/7
INFLATABLE LIFERAFT TESTS IN THE PACIFIC OCEAN OFF THE COLUMBIA--ETC(U)
MAY 78 R L MARKLE, S E WEHR, M R DANIELS

UNCLASSIFIED USCG-M-4-78 NL

1 OF 1
AD
A055 323

END
DATE
FILMED
8 -78
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FOR FURTHER TRAN

Report No. CG-M-4-78

25

INFLATABLE LIFERAFT TESTS IN THE PACIFIC OCEAN OFF THE COLUMBIA RIVER BAR

May 3, 1978

Document is available to the public through the
National Technical Information Service,
Springfield, Virginia 22151

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

NOTICE

Technical Report Documentation Page

1. Report No. CG-M-4-78	2. Government Accession No. 14 USCG-M-4-78	3. Recipient's Catalog No.
4. Title and Subtitle 6 Inflatable Liferaft Tests in the Pacific Ocean off the Columbia River Bar		5. Report Date May 3, 1978
		6. Performing Organization Code
7. Author(s) 10 R. L. MARKLE, S. E. WEHR, M. R. DANIELS, S. G. MANESS		8. Performing Organization Report No.
9. Performing Organization Name and Address		10. Work Unit No. (TRAIS)
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Department of Transportation, Office of Merchant Marine Safety, United States Coast Guard, 400 Seventh St., S.W., Washington, D.C. 20590		13. Type of Report and Period Covered 9 Final Report, 23 JAN 78 - 27 JAN 78
		14. Sponsoring Agency Code

15. Supplementary Notes

11 3 May 78 12 27p.

16. Abstract

This report presents the results of various exercises with inflatable liferafts having large water ballast systems for improved stability. The exercises were conducted in the Pacific Ocean near the Columbia River Bar. The report describes the exercises in detail and analyzes the results. The investigation described is one of a planned series of investigations into the characteristics of inflatable liferafts in heavy winds and high seas.

17. Key Words		18. Distribution Statement
Inflatable liferafts	Survival	UNLIMITED
Liferafts	Abandon-ship	Document is available to the public through the National Technical Information Service, Springfield, VA 221515
Capsizing		
Stability		

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	22	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

78 06 09 010

406 934

ERRATUM

An incorrect version of Figure 1 appeared in an early printing of this report which is marked "ADVANCE PRINT" on its cover. The incorrect figure showed baffles in the ballast bag of the raft. The raft actually did not have such baffles. Figure 1 is correct as it appears in this report.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

This report discusses a series of exercises conducted on inflatable liferafts having differing underwater ballast systems for stability. The exercises were conducted during the week 23 January 1978 in the Pacific Ocean just off the Columbia River Bar. The operation was based at U.S. Coast Guard Station, Cape Disappointment near Ilwaco, Washington.

The exercises were intended to demonstrate two different life raft ballast system concepts in heavy seas. The location was chosen as having a high probability for the sea conditions desired at some time during the week. A fair weather system dominated the area during the week, so the desired sea conditions never materialized, but the exercises were carried out in the general vicinity of a jetty, where the effects of the jetty and a sloping beach created some breaking waves.

The authors extend their appreciation to the personnel at Cape Disappointment whose cooperation enabled the exercise to be successfully completed, despite the heavy personnel demands of running a lifeboat training school and entertaining reporters and photographers from two newspapers and a magazine during the week.

2. OBJECTIVES

The operation was structured as an exercise rather than a formal test. No rigorous guidelines were established as to what was to be accomplished and how. The general objectives were to:

(a) Make observations of the behavior of the rafts in heavy seas.

(b) Obtain experience handling the rafts in heavy seas in order to be better prepared for more rigorous future tests.

(c) Provide some initial data on life raft performance in heavy seas to be used as background information for the formal raft stability evaluation planned to start later in 1978.

(d) Make film and/or videotape records from the surface and from the air of the rafts in heavy seas.

(e) Determine whether or not a ballast system could be incorporated into rescue rafts used by the Coast Guard without interfering with the normal function of the raft.

The exercise was considered to be strictly preliminary, with no intention of making a final determination on the relative merits of ballast systems in general or particular types of ballast systems.

3. DESCRIPTION OF THE LIFERAFTS

The following rafts were used in the exercise:

(a) A 4-person liferaft manufactured by the Switlik Parachute Company, Inc. The raft had been procured in limited quantity by the Coast Guard for evaluation for use by operational units as a rescue raft. The body and canopy of the raft are similar to the small Coast Guard approved rafts produced by Switlik, except that the canopy can be rolled down so that the raft is open with nothing overhead but the canopy support tubes. The raft was modified by Givens Res-Q-Raft by addition of a Givens Buoy Ballast Chamber. The arrangement of the bottom of the raft is illustrated in Figure 1. This ballast chamber differs from the standard Givens chamber in that it was fitted with a deballasting arrangement to allow water to flow out of the bag more easily in order to facilitate towing and recovery. The deballasting arrangement consists of a slit in the back end of the buoy which is laced together with a lanyard that can be pulled from inside the raft. When the lanyard is pulled, a weak link in the lacing is supposed to break to allow the lacing to be pulled out, opening the slit. The raft was also fitted with a special towing bridle intended to distribute the towing load better than the standard webbing towing bridle provided by Switlik. The special towing bridle was fabricated by Givens Res-Q-Raft and consisted of 3/8-inch polypropylene line attached to the raft at 6 patches on the tubes. The patches appeared to be 2000-lb. nominal attachments. This raft is designated S-G.

(b) A 4-person liferaft manufactured by the Switlik Parachute Company, Inc. The body and canopy of this raft were identical to those

of the raft described in the previous paragraph, but differed from the other in the stabilizing system fitted to its bottom. The stabilizing device was designed by Switlik and is designated as a "Toroidal Stabilizing Device". The device is pictured in Figure 2. Unlike the Givens device which has been in existence for several years, the Switlik device was a new design and this exercise is believed to be its first trial at sea. The raft is designated as S-S.

(c) A standard Givens 4-6 man liferaft manufactured by Givens Res-Q-Raft. This raft also had the Givens Buoy Ballast Chamber as illustrated in Figure 1. It did not have the special deballasting arrangement as did raft S-G. This raft was not initially intended to be involved in the evaluation, but Mr. Givens, president of Givens Res-Q-Raft, provided it for whatever use could be made of it. This raft is designated G-G.

4. DISCUSSION OF EXERCISES

4.1 Weather and Sea Conditions

The location of the exercises at the Columbia River Bar was selected because of the notorious sea conditions that persist there. The offshore motor lifeboats at this station are of the self-righting, self-bailing design which has shown its value in numerous capsizing and rerighting incidents in the steep breaking seas that can form over the bar.

The weather during the week was dominated by a stationary high pressure system centered to the northwest of the mouth of the Columbia River. This brought generally fair weather to the area accompanied by offshore winds. The winds tended to keep down the size of the swells moving against the wind, toward shore. Under these conditions, the seas during most of the week were reported as 6 to 10 foot swells moving generally from west to east. The lone exception to this was Wednesday, January 25, when some light showers and fog were in the area and the wind direction shifted. On this day, the swells increased to 10 to 15 feet.

Because of the weather and sea conditions, the project team spent Monday and Tuesday doing hypothermia experiments at the dock at Cape Disappointment. The main part of the excercise was held on Wednesday when the weather picked up.

4.2 Surf Exercise - Raft G-G.

On Tuesday, January 24, Mr. Givens, who was not involved in the hypothermia experiments going on at the time, took Raft G-G and joined the surf swim exercise that was taking place that day for the lifeboat training school. In the surf swim, the lifeboat crews in train-

ing are taken out off the beach just past the breaker line. There they are put over the side of the boat and must swim to shore in their wet suits. No members of the project team were with this surf swim exercise.

The raft was inflated and taken to the site of the exercise (Figure 3, area 4.2). Mr. Givens reported that the raft was put over the side of the boat outside the breaker line and was taken into shore by the surf. A line was then passed to the raft from the boat which then towed the raft back out through the breakers where it was taken aboard the boat. Mr. Givens reported that the raft performed very well during this exercise, did not capsize, was able to be towed sucessfully and brought aboard the boat with a minimum of difficulty.

After the raft was brought back to the station and deflated, it was examined. Some damage to the ballast chamber was noted. In particular, one of the flapper valve attachments was torn, and one of the filling holes for the initial stabilization stage near the bottom of the raft body had two rips radiating from it, one in the horizontal direction (parallel to the waterline), and one in the vertical direction, extending downward from the hole.

4.3 Preliminary Exercise - Raft S-S.

On Wednesday when the seas picked up somewhat, the two modified Switlik rafts (S-G and S-S) were taken out toward the ocean aboard a 44-foot motor lifeboat. A 52-foot motor lifeboat carried observers and was intended to escort and assist the 44-footer as needed. A Coast

Guard photographer was to be taken aboard an H-3 helicopter to record the exercise on videotape. While the two boats were proceeding to sea, the use of the helicopter for photography was lost to a training exercise being conducted by the lifeboat school. The 52-footer returned to the dock to pick up the photographer so that the taping could be attempted from the surface. While this was going on, the 44-footer was ordered by operations not to proceed beyond the end of the jetties. It was decided to launch Raft S-S and conduct some limited exercises while awaiting the return of the 52-footer. These exercises took place in area 4.3 in Figure 3. In this protected location, moderate swells were experienced; there were no breakers.

The raft was put over the side where Mr. Maness boarded it. The raft rode the slight swells in this area very easily and comfortably. Mr. Maness unsuccessfully attempted to overturn the raft by hanging out to one side; Mr. Givens then entered the raft to assist in this attempt. The raft tipped to the side the two were on to an angle of about 30° from the horizontal. The raft was prevented from overturning by the water trapped in the baffled chambers on the high side. It was then attempted to create some more severe conditions by running the 44-footer around the raft, creating about a 6-foot wake. The raft continued to be stable in these conditions, and the continued attempts of the two individuals to overturn the raft were unsuccessful. The raft was then towed about a half-mile to get it out of the main channel where it had drifted, Mr. Maness then left the raft and allowed Mr. Givens to continue to try to overturn the raft. His subsequent attempts were also unsuccessful.

While this exercise was going on, the 52-footer had arrived at the dock and had begun preparation to take the photographer and his gear aboard. At this time, another helicopter was made available to the exercise at Air Station, Astoria, Oregon. Plans to put the photographer aboard the 52-footer were abandoned, and the photographer loaded his gear into a car for the 45-minute drive to the air station. As the 52-footer returned to area 4.3, Raft S-S was taken back aboard the 44-footer.

4.4 Open Sea Exercise - Rafts S-G and S-S.

The two boats proceeded to the southern end of the area identified as 4.4 in Figure 3. The seas were running 10 to 15 feet in this area and took the form of long swells with some just beginning to crest. The swells did break closer to the jetty and the beach to the north of the jetty creating a very heavy rolling surf. Both rafts were launched fairly close together with the canopies lowered and approximately 330 lbs. of sand bags in each to simulate half-loaded rafts. Mr. Givens, noting that Raft S-G did not have a sea anchor, severed the sea anchor line on Raft S-S. Both rafts rode the swells very easily, were not affected by the cresting swells, showed no tendancy to overturn, and drifted very close to each other. Neither raft approached the area of the breakers and they seemed to be in a circular eddy-like current that would first move them south toward the main channel, and then move them north to an area just off the north jetty.

In an effort to get the rafts into rougher water, it was decided to tow them further north. Raft S-S was taken into tow by the 52-footer and moved at full throttle (approximately 12 knots) to a location that was perhaps one-half mile north of the area where the rafts had originally been launched. The 44-footer took Raft S-G into tow and moved it a short distance before the belayed towing line was pulled off its bitt by the resistance of the raft. Towing of the raft was complicated by the fact that the one-inch diameter nylon towing line was only about 20 feet long, forcing the raft to ride right in the wake of the boat and causing a lot of water to be shipped over the upper tube, filling the raft with water. In a second attempt to tow the raft, an eye was made in the end of the towing line which was then placed over the bitt post. After towing the raft a short distance, the towing bridle on the raft parted at four of the six attaching points. It should be emphasized that this towing arrangement was somewhat of a makeshift affair that had been rigged to better withstand the resistance to towing caused by the filled ballast chamber. The Switlik raft body and towing bridle had not been specifically designed for the Givens Buoy arrangement. The attachment points that failed were represented by Mr. Givens to have been glued into place just a few days before this test and were therefore somewhat "green".

The third attempt to tow the Raft S-G was made using the boarding ladder on the raft that is made of webbing, which is the normal towing point for the Switlik raft. This arrangement also gave way, having not been designed for the resistance it encountered. Next, Mr. Givens

entered the raft and attempted to operate the deballasting arrangement to dump the ballast chamber. However, the weak link had been made of thin nylon line and would not break. Repeated attempts to deballast were unsuccessful. One more attempt to use the boarding ladder webbing at an unbroken point also resulted in the breaking of the webbing. Then followed an attempt to attach a tow line by putting a loop of it around the raft, but by that time currents in the area had taken the boat and the raft dangerously close to the end of the north jetty and this effort had to be abandoned. One last attempt was made to move the raft by pulling it back aboard the boat, but this attempt also failed. It was possible to pull the raft partly out of the water and dump some of the water from the occupant area of the raft, but it appeared that considerable water remained in the ballast chamber, which prevented the raft from being lifted into the boat. It was felt that the raft would eventually drift onto the jetty or onto the shore where it could be picked up later.

In the meantime, it was reported that mechanical difficulties with the helicopter assigned to the photographer would prevent it from flying. It was decided to end the exercise at this point. The 52-footer picked up Raft S-S and proceded back to the dock at Cape Disappointment.

The 44-footer stood by some distance away from the jetty and observed Raft S-G as it moved into the area of the rolling surf just off the end of the north jetty. One of these waves broke over the raft and it disappeared from sight. After several seconds it reappeared upside down with the ballast chamber laying flat on the upturned bottom

of the raft (see Figure 3). From the location of the observers on the 44-footer, it was not possible to tell if the ballast chamber was laying flat on the floor of the raft, or whether water was still contained in the floor distended under the cover of the chamber material. When upside down, this raft will normally float on its canopy support tubes. The fact that it was flat on the water suggests that the canopy tubes were collapsed, and at least some water was weighting the raft down between the ballast chamber and the floor. An alternate explanation could be that the raft was held to the surface by suction in the occupant area.

4.5 Recovery of Raft S-G.

Several hours later, Raft S-G washed onto the north side of the North Jetty where it was recovered by land (see Figure 3). By the time it had reached the jetty, it had righted in the surf and the occupant area was filled with water and one or two small logs. No one saw the raft reright. The raft had been caught for some time in an eddy just north of the jetty with a large amount of floating debris including logs 8 to 12 inches in diameter and several sea otters and sea lions. When the raft was recovered, it was discovered that several of the attachments of the flapper valve had broken, indicating that movement of the raft and the resulting pressure on the ballast chamber had broken them. There were also tears radiating from two holes for filling the initial ballast stage. These tears were located about 90° around the raft from the towing point. One of the tears was horizontal, parallel to the waterline and connected the two holes. The other tears extended downward from the same two holes

and stopped at a seam. This damage is illustrated in Figure 4. Other than this, the raft was in good shape. There was no noticeable loss of pressure in the tubes including the canopy support tubes which were upright and firm. The similarity of the damage to this raft and the damage that occured to raft G-G as reported in Section 4.2 should be noted.

5. ANALYSIS AND CONCLUSIONS

5.1 Performance of Raft S-G.

The capsizing of raft S-G will be one of the most controversial aspects of this exercise. The Givens Buoy System has been heavily advertised as being a great improvement over conventional stabilizing devices for inflatable liferafts. Under one set of conditions in another test, where deployed rafts were subjected to high winds generated over calm water, this claim for improved stability has been shown to be true.1/ The conclusion from the present exercise must be that although the ballast chamber may improve rough water performance, the ballast chamber as it was installed on raft S-G does not guarantee that the raft will never overturn. In this connection the following observations must be made:

(a) No conclusion can be made with regard to the relative performance of Raft S-G in comparsion with a raft of any other design. Neither Rafts S-S nor G-G was subjected to the heavy rolling breakers in which Raft S-G overturned.

(b) It can not be determined with certainty whether or not the flapper valve was intact when the raft overturned, so the effectiveness of the ballast system at that time cannot be determined. It must be assumed, however, that even if the flapper was open, the water in the ballast chamber would be restricted from leaving by the office

1/ Daniels, M.R., et al., Preliminary Tests of Inflatable Liferafts for Stability in High Winds, Department of Transportation, Office of Merchant Marine Safety, U.S. Coast Guard, Report No. CG-M-1-78, NTIS No. AD A048722, December 1, 1977.

effect of the opening, so that some degree of stabilization would be present in any event. The difficulty in towing the raft and the inability of three men to pull the raft aboard the boat suggest that the flapper valve was intact before the raft was set adrift. However, the similar damage to Raft G-G which did not overturn but was towed and subjected to breaking waves, presents the possibility that the damage to Raft S-G was not coincident with its capsizing. The present evidence suggests that the damage was caused by wave action just prior to capsizing, and that the reduced (but not totally eliminated) effect of the ballast contributed to the eventual capsizing.

(c) Another possibility is that the flapper valve attachments were intact during the capsizing and were broken sometime between the capsizing and the eventual rerighting of the raft before its recovery. This possibility is suggested since no one on the 44-footer observed the flapper valve out of place after it capsized. Furthermore, some observers have suggested that the pattern of damage to the flapper valve attachments shows that the damage was caused by an inward force on the flapper. Such a force could be generated by seas breaking over the capsized raft.

(d) The tearing of the initial ballast stage between filling holes would probably not have affected the stability of the raft significantly when the ballast chamber was full. This damage could have possibly been caused by the floating debris in the area where the raft was recovered, but the similiarity of this damage to the damage sustained by Raft G-G indicates that the tears probably occurred earlier. It is noted that the holes could be high stress points when the body of the raft is twisted and the ballast chamber has not had a chance to move, such as would

occur when the slack is taken up on a towing line and the raft is not aligned in the direction of towing. Since rip-stop material was not used in construction of the ballast chamber, small rips could easily propagate into long ones.

(e) A different choice of materials and design detail could possibly prevent the kind of damage that occured to the ballast chamber.

(f) Raft S-G had water in the occupant area when it overturned and this may have resulted in a significant loss of stability. The canopy of the raft was down during the entire exercise, and the raft shipped a lot of water that would have been prevented from entering if the canopy had been up.

(g) Some detractors of the Givens system have suggested that when a heavily ballasted raft overturns, it will be dragged under by the action of the waves, turned over, and when it surfaces again upside down, the water in the ballast bag will be dumped on the occupants, crushing or trapping them. It could not be determined by the observers how far the raft was actually dragged under, or whether it was merely covered by a wave breaking on top of it. It was also not possible to determine whether or not there was any water in the ballast chamber after it overturned. The chamber material appeared to be laying flat, but it could have either been laying directly on the raft floor or floating on top of water contained between the ballast chamber material and a distended floor.

(h) The sea conditions at the place where the raft overturned were due to bottom effects and may not be representative of deep sea wave action.

(i) The ballast chamber was installed on a Switlik raft, not on a Givens raft.

(j) The towing of Raft S-G was highly unsatisfactory. The resistance of the ballast chamber full of water to moving makes towing difficult. When the raft is under tow, it tends to plow through the water rather than skim the top like most rafts. It would be desireable to improve the towing characteristics of the raft, but stability when drifting should still be the most important consideration for a survival raft on a commercial vessel.

5.2 <u>Performance of Raft S-S</u>.

Raft S-S performed well throughout the exercise, however, its rough water stability cannot be evaluated against that of the Raft S-G at this time because it was not subjected to the same severe conditions as was Raft S-G. In the exercise described in Section 4.3, it was shown to have very good static stability. Other rafts of the same size without ballast chambers or with very small ballast chambers have been easily turned over by one person leaning out. The improvement in stability was evident. The towing performance of the raft was very satisfactory, which is important for Coast Guard rescue rafts that may be drifted into shallow areas to pick up stranded survivors and then must be towed out. On the basis of these observations, the Switlik Toroidal Stabilizing Device was selected for use on life rafts for Coast Guard rescue boats. These rafts are to be procured in the near future.

Raft S-S shared the same upper body construction with Raft S-G. Therefore in view of the harsh treatment of Raft S-G as discussed

previously, it is concluded that Raft S-S is of sufficiently robust constrction to perform well as a rescue raft for Coast Guard operational units.

5.3 Accomplishment of Objectives

(a) The objective of observing life raft behavior in heavy seas was only partially accomplished because of fair weather in the area most of the week. The capsizing of Raft S-G did show what might happen in rolling seas, but it was an event that was not observed at close range (1000 ft. estimated) and it occurred in waves that were influenced by the bottom effect and may not have been representative of deep sea conditions. The 10 to 15 ft. swells in deeper water presented no problem for either raft.

(b) Handling the rafts proved to be not too difficult with the exception of towing Raft S-G and removing it from the water. For test purposes, it seems that a better way is needed to move this raft. Since there were two boats, the two rafts were not difficult to track. In the opinion of the authors, it would have been possible for each boat to handle one more raft efficiently, but no more.

(c) This report will add some information to what is already known about the behavior of inflatable liferafts at sea, and it raises questions about certain technical problems that need to be further investigated.

(d) Because of lack of helicopter availability the aerial photography was not made. Some of the observers on the 52-footer had still and motion picture cameras and they did record parts of the exercise. The capsizing was not recorded on film. None of the still pictures adequately conveys the the size of the seas. Some of the movie shots

do give one a feel for the conditions when they were taken in a direction parallel to the line of the waves. For greatest effect, future photography of similar exercises should emphasize shots taken in this direction.

(e) As discussed in 5.2, it was decided that the ballast system on Raft S-S would be a suitable addition to the Coast Guard rescue rafts.

5.4 Future Work

Ballast systems have great potential for improving liferaft stability. The goals of future work in this area must be to establish:

(a) How much ballast is required?

(b) How should the ballast water be held and distributed?

(c) Are there any aspects of ballast systems that introduce new hazards, and if so, how can they be reduced?

(d) Can ballast systems be effective when the raft is first inflated, the time when casulty records show that many inflatable rafts have been carried away?

One aspect of future work that is very important at this point is the establishment of a theoretical basis for liferaft stability, both with and without ballast systems. Work on this aspect of the problem is expected to begin in late 1978. This will give future at-sea tests better direction.

One thing that was lacking from this exercise was a flat bottomed or lightly ballasted raft. Such a raft would be valuable to observe alongside the ballasted rafts to give a better feel for the effect of ballast systems on raft performance.

6. COMMENTS BY MANUFACTURERS

Equipment manufactured by Switlik Parachute Company and Givens Res-Q-Raft was used in this test. These companies were given a chance to review the preliminary draft of this report. Widely differing opinions on the test results were expressed. This was not unexpected since the report contains the first known account of a capsizing of a liferaft with a Givens Buoy Ballast System which has been extensively advertised as a great improvement over more conventional designs. The verbatim comments from these two companies are available from the authors on request at the following address:

U. S. Coast Guard Headquarters
G-MMT-3/83
Washington, DC 20590

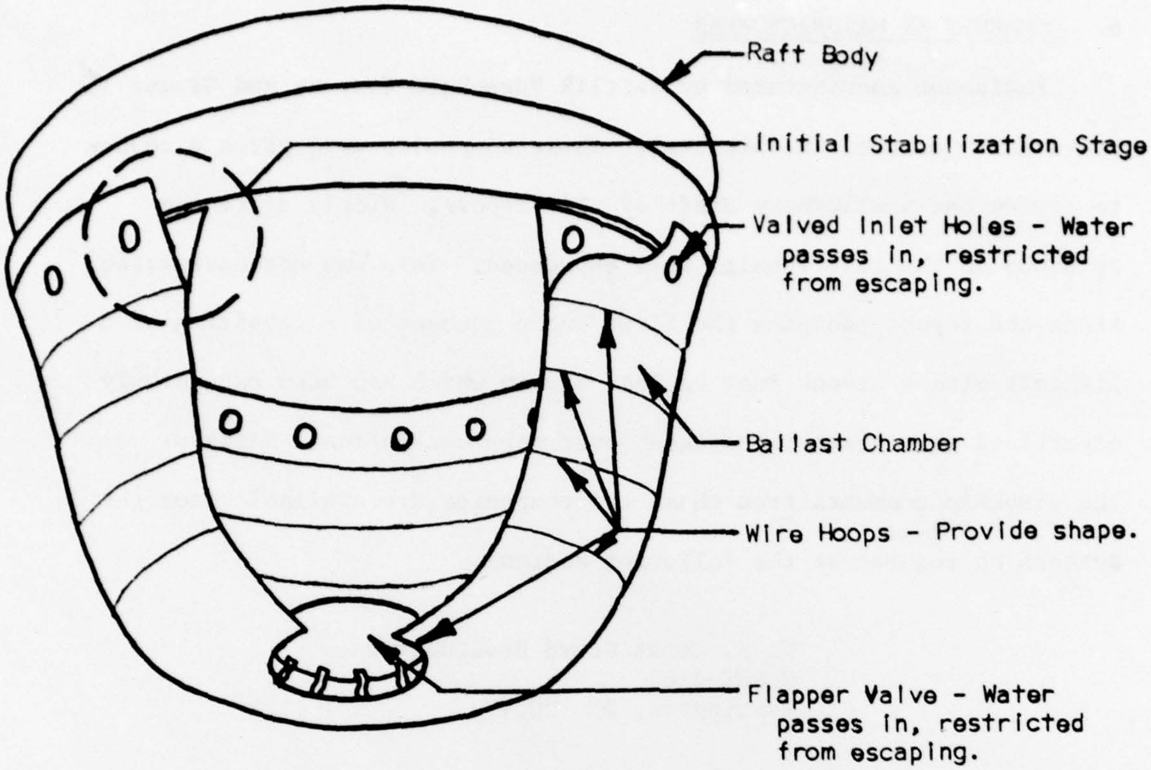


FIGURE 1. Givens Buoy System on Rafts S-G and G-G (Simplified cutaway view of raft bottom: canopy and certain design details not shown).

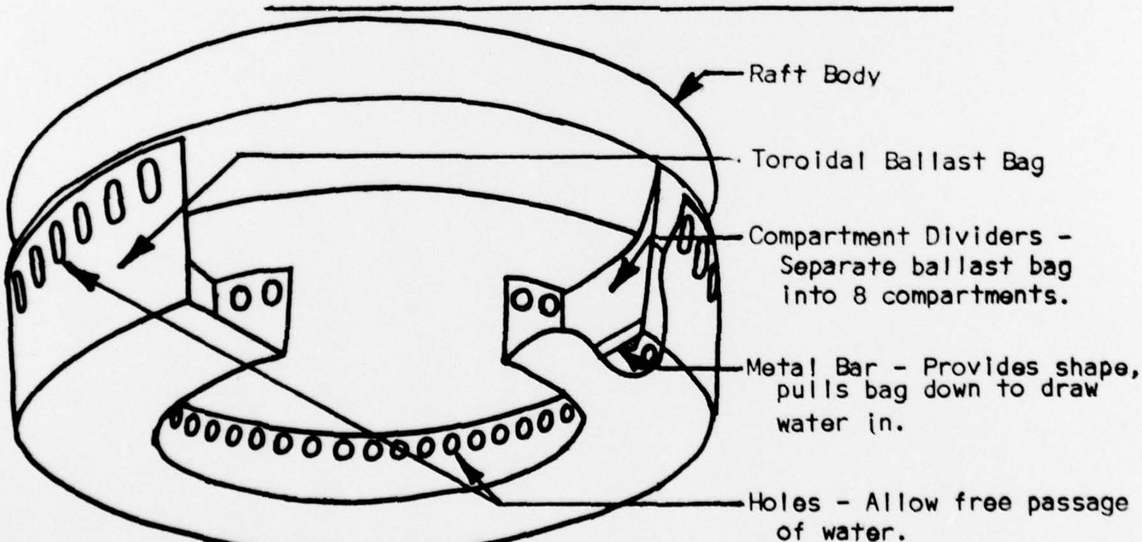


FIGURE 2. Switlik Toroidal Stabilizing Device on Raft S-S (Simplified cutaway view of raft bottom: canopy and certain design details not shown).

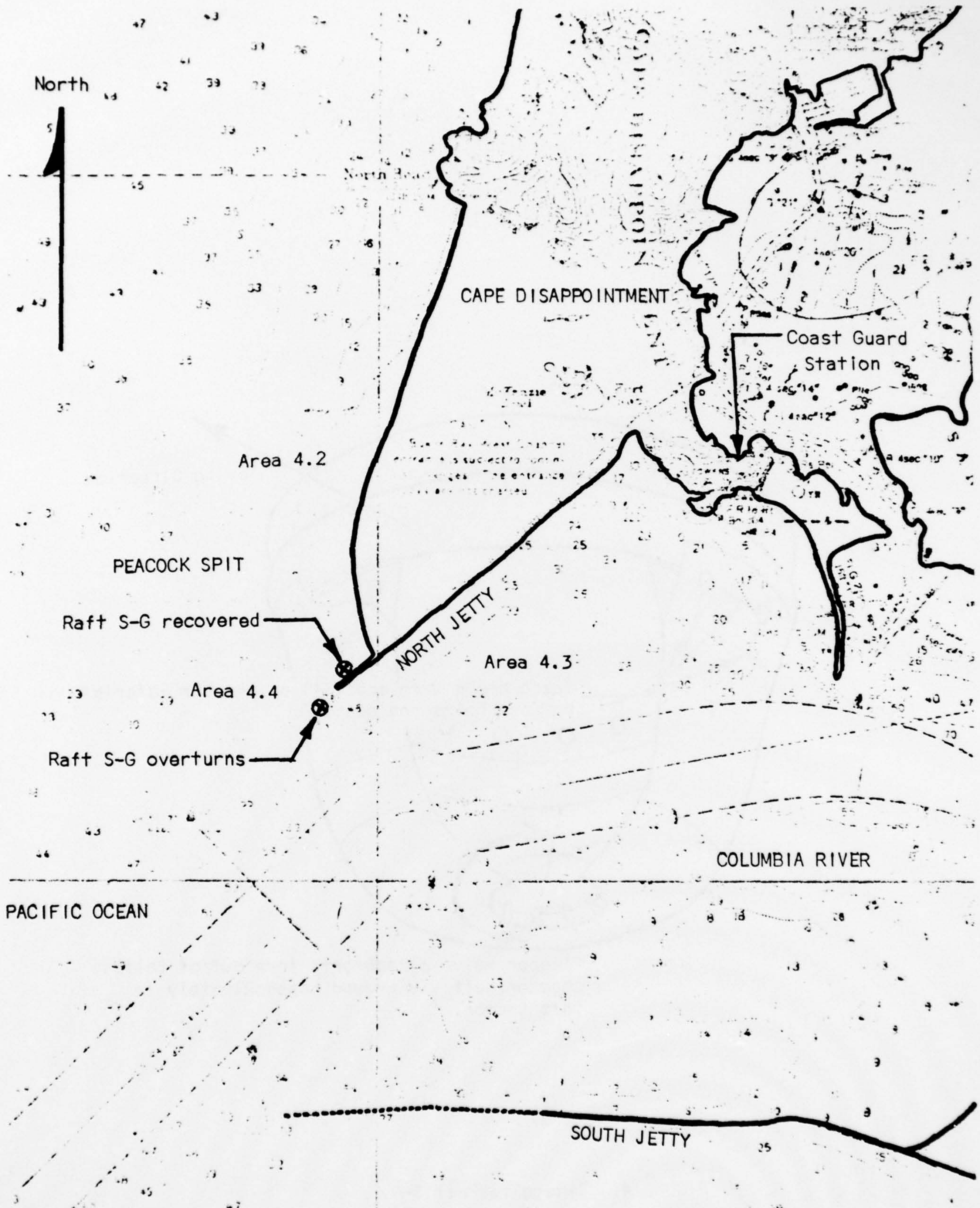


FIGURE 3. Chart of Columbia River Bar Area

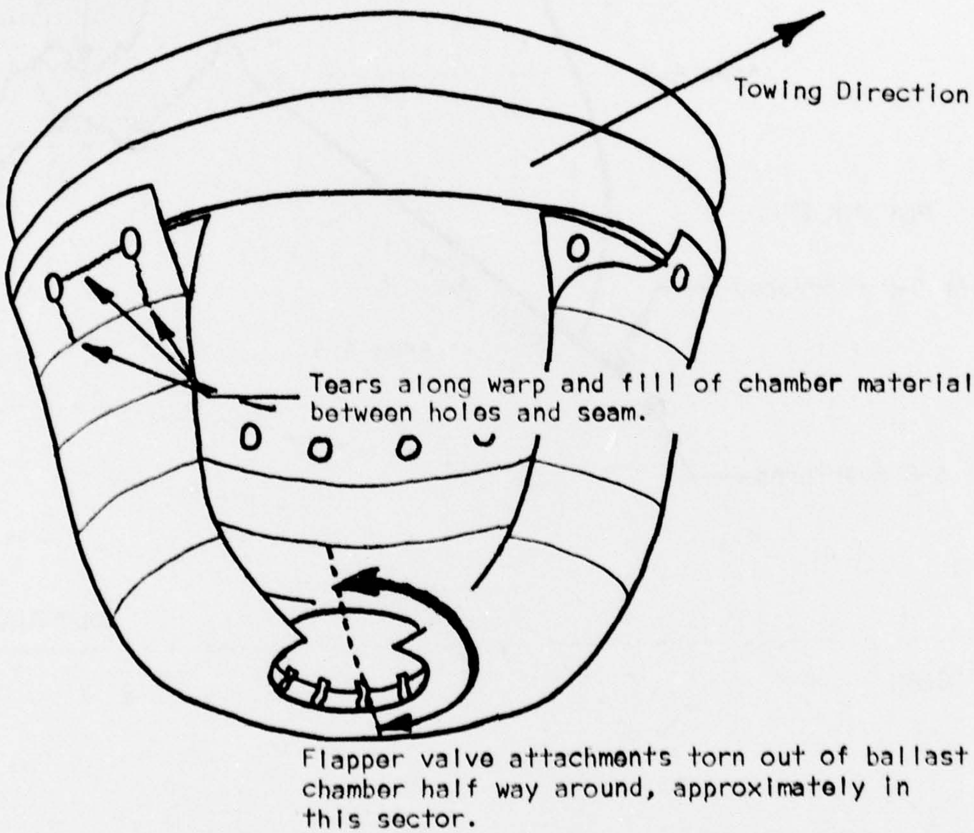


FIGURE 4. Damage to Raft S-G.